→ MARCDAT-III

Third International Workshop on Advances in the Use of Historical Marine Climate Data

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ABSTRACT BOOK

Front Page Image Information

Upper (left to right):

- *US steam frigate Mississippi, in the Gulf of Mexico, March 1847: Library of Congress, Prints & Photographs Division [reproduction number LC-USZC2-3129] (originally published by N. Currier, New York, 1848).*
- *Florida peninsula, January 1985: NASA Space Shuttle Earth Observations Photography database [photo STS51C-44-0026].*
- *TAO (Tropical Ocean Atmosphere) buoy and anemometers on NOAA ship Ka'imimoana. Photo by Jason Poe, courtesy of TAO Project Office.*

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Session A: Introductory

WMO activities in support of marine climate data

Etienne Charpentier (WMO Secretariat)

The presentation will provide an overview of WMO activities in support of marine climate data. It will provide details on the WMO strategic objectives expected to by approved by the WMO sixteenth Congress (Geneva, 16 May – 3 June 2011) for the next financial period (2012-2015), and in particular its third strategic thrust *"Advancing scientific research and application, as well as development and implementation of technology"* and fourth Expected Result *"Enhanced capabilities of Members to access, develop, implement and use integrated and interoperable Earth- and space-based systems for weather, climate and hydrological observations, as well as related environmental observations, based on world standards set by WMO"*.

The WMO sixteenth Congress is also expected to decide on five strategic priorities including in particular the Global Framework for climate Services (GFCS), and the implementation of the WMO Integrated Global Observing System (WIGOS). WIGOS will establish an integrated, comprehensive and coordinated observing system to satisfy in a cost-effective and sustained manner the evolving observing requirements of WMO Members, and will enhance coordination of WMO observing systems with those of partner organizations, such as the Intergovernmental Oceanographic Commission (IOC) of UNESCO, for the benefit of society. Ocean data, and historical marine climate data in particular are expected to play a crucial role in the developing Global Framework for Climate Services (GFCS) that is now developing following the recommendations from the Third World Climate Conference in 2009. Details will be provided on the recommendations from the High Level Task Force (HLT) that was set up for the GFCS following the third World Climate Conference (WCC-3) in late 2009.

The future WMO priorities, together with the WMO Information System (WIS) are directly relevant to MARCDAT as marine climate data and metadata are required for the GFSC, need to be exchanged, discoverable, accessed, and retrieved in an interoperable way through the WIS, and need to be produced according to harmonized standards and practices, and uncertainties understood in line with WIGOS requirements.

The presentation will also focus on requirements for marine data, including marine climatological data for a number of WMO applications. Information will be provided on WIGOS and its implementation in the next four years; as well as on the current status of WIS implementation and plans. The role of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) with regard to WIS and WIGOS will be explained, including the legacy recommendations from the Pilot Project for the integration of marine meteorological and other appropriate oceanographic observations into WIGOS (also known as the JCOMM Pilot Project for WIGOS). For example, the JCOMM Pilot Project for WIGOS has identified the UK and Germany Global Collecting Centres (GCCs), and the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) as key ocean data sets where interoperability should be developed with the WIS and/or the Ocean Data Portal of IOC.

Finally, the presentation will provide information on JCOMM priority activities within its Observations Programme Area (OPA), and its Data Management Programme Area (DMPA), and introduce the role of the JCOMM *in situ* Observations Programme Support Centre (JCOMMOPS). It will also provide some details on the role of other WMO Commissions (CCl, CBS, CIMO) with regard to marine climatology.

IOC/IODE perspectives on long term ocean climatic data sets

Sissy Iona, JCOMM/DMPA Coordinator, IODE Co-Chair

Established in 1961, the International Oceanographic Data and Information Exchange (IODE) Programme of the Intergovernmental Oceanographic Commission (IOC) supplements 50 years services of providing ocean data, information and services to the users' community.

The main objectives of the IODE Programme are:

i. to facilitate and promote the exchange of all marine data and information including metadata, products and information in real-time, near real time and delayed mode;
ii. to ensure the long term archival, management and services of all marine data and information;
iii. to promote the use of international standards, and develop or help in the development of standards and methods for the global exchange of marine data and information, using the most appropriate information management and information technology;
iv. to assist Member States to acquire the necessary capacity to manage marine data and information and become partners in the IODE network; and
v. to support international scientific and operational marine programmes of IOC and WMO and their sponsor organisations with advice and data management services.

Being a worldwide service oriented network, the IODE system consists of National Oceanographic Data Centres (NODCs), Designated National Agencies (DNAs), the former World Ocean Data Centres (ICSU) as well as Marine Libraries and Information Centres. Currently, more than 80 oceanographic data centres in as many countries have been established enabling the collection, quality control, archiving, and exchanging of millions of ocean observations between the Member States and collaborative Parties and Networks.

Among the major and long-term commitments of the IODE Programme is the long-term archival, management and accessibility of past, present and future marine data and information holdings against loss or degradation. A variety of international projects such as GODAR, GTSPP, GOSUD, etc have been established and carried out within IODE programme with the aim to develop and maintain complete, global, long-term data sets, products and services. Furthermore with the application of modern web oriented information technologies, IODE community is building the Ocean Data Portal (ODP) which interlinks the distributed data sources and provides seamless access to real-time, delay-mode and historical collections and inventories of marine data that are managed within the IODE network. Thus, ODP contributed to the WIGOS Pilot Project for JCOMM by providing oceanographic data and services to the WMO Information System (WIS). In addition, IODE jointly with JCOMM implements the Ocean Data Standards Pilot Project to develop community-wide standards for marine data and information management and exchange.

The presentation will provide a detailed insight at the present IODE infrastructure and activities related to the management and provision of long term climatic ocean data to support the study of climate variability and change.

The JCOMM in situ Observing Programme Support Centre (JCOMMOPS)

Mathieu Belbeoch, JCOMMOPS
Etienne Charpentier, WMO Secretariat

This presentation will provide information on the JCOMM in situ Observing Programme Support Centre (JCOMMOPS) and how it contributes to enhancing synergies between different ocean observing systems. JCOMMOPS was initially established in 2001 by the first Session of the joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) to establish synergies between the Data Buoy Cooperation Panel (DBCP), the Ship of Opportunity Programme (SOOP) and the Argo profiling float programme, and enhance integration of operations and implementation by providing day to day support at the international level to the *in-situ* marine observing systems coordinated under these programmes, namely drifting buoy, moored buoys in the high seas, ships of opportunity, and profiling floats. The JCOMMOPS is acting as a focal point on those aspects.

In 2005, JCOMM-II extended the JCOMMOPS Terms Of Reference to include coordination for the JCOMM Ship Observations Team (SOT) as a whole, and to provide information on satellite data requirements.

In 2009, JCOMM-III again expanded its Terms of Reference to further enhance the synergies with other JCOMM Observations Programmes such as the International Ocean Carbon Coordination Project (IOCCP), the Global Sea Level Observing system (GLOSS), and the OceanSITES provided appropriate resources are identified to realize such support. New activities shall also include system performance monitoring, system design evaluation to improve system efficiency and effectiveness. Better links shall be provided with the space agencies regarding the dissemination of information on satellite data requirements, and satellite information services through the JCOMMOPS web site.

Ten years after JCOMMOPS establishment, a number of services have been rendered by the centre including support to programme planning, implementation, and operations essentially through direct contact with national programme operators, technical assistance, and the provision of technical information on (i) observational data requirements, (ii) technology, instrumentation, and costs, (iii) operational status of observing networks (e.g. identification of gaps in terms of space-time resolutions, data timeliness, etc), and (iv) instrument deployment opportunities (by ship and air).

JCOMMOPS is assisting with regard to real-time distribution of the data to international users, the collection of instrument/platform metadata and their submission to the official JCOMM long term archive centres. It provides a mechanism for relaying quality information from data centres and users worldwide, back to platform national operators.

Through its activities, JCOMMOPS participates in the overall integration efforts called by the IOC-WMO-UNEP-ICSU Global Ocean Observing System (GOOS), and the WMO Integrated Global Observing system (WIGOS), and needed in particular to provide the required observations to the Global Framework for Climate Services (GFCS).

Priorities, challenges, ideas to enhance further those synergies in the next decade will be presented and discussed.

Global Ocean Fundamental Climate Data Records

David Halpern, NASA Headquarters, Washington, DC, USA

A fundamental climate data record (FCDR) is a long-term data record involving a series of platforms, such as satellite and in-situ instruments each with different performance characteristics, usually with different space and time sampling, time extent, and stability. On many occasions different agencies build different platforms measuring the same variable. A homogeneous, well-characterized FCDR for climate studies requires knowledge of accuracy, errors, precision, reliability of continuity, completeness, sustained calibration, reprocessing, stability traceable to international standards, open and transparent peer-review documentation, accessibility and reproducibility. The European Space Agency (ESA) Climate Change Initiative (CCI) has eleven essential climate variables. In this talk, the following ESA CCI variables are defined to be global ocean essential variables: sea level, sea ice, sea surface temperature and near-surface phytoplankton abundance. Additional ESA CCI essential climate variables are important for understanding the unprecedented changes occurring in the ocean, e.g., greenhouse gases, glaciers and ice gaps, and clouds. The maximum time duration of such global ocean satellite datasets will be 32 years in October 2011, requiring long-term calibration and stability of the FCDRs. I shall describe how the marriage of in-situ and satellite data is critical to enhance the quality of ocean in-situ and satellite FCDRs. Principles that enable climate-quality data will be discussed.

Session B: The ESA CCI and other satellite data

The European Space Agency's Climate Change Initiative Project for Sea Surface Temperature (SST CCI)

Merchant, C J[1]; Rayner, N[2]; Corlett, G[3]
[1]The University of Edinburgh, UNITED KINGDOM; [2]Met Office, UNITED KINGDOM; [3]University of Leicester, UNITED KINGDOM

In 2009, the European Space Agency (ESA) invited tenders for a project on sea surface temperature within its Climate Change Initiative (CCI). Overall, the CCI aims to:

1. develop validated methods to derive global satellite-based products for selected Essential Climate Variables (ECVs)
2. apply these methods in an R&D context to give useful climate data records
3. optimize the impact of ESA earth observation missions on climate data records
4. generate specifications for future systems to deliver these climate data records operationally
5. to strengthen inter-disciplinary co-operation between international earth observation, climate research and modelling communities, in pursuit of scientific excellence

Sea surface temperature (SST) is one of several ECVs in the CCI, and the SST CCI project started in August 2010. There are 8 collaborating organisations in the project, which is led by the University of Edinburgh.

The SST CCI project follows a structured sequence: climate user consultation, product specification, open methodological development, prototype system development, application to creation of SST climate data records, and climate user involvement in appraising and using the SST CCI products.

The initial user consultation phase has led to a User Requirements Document, which identifies a range of areas in which current SST data records need improvement -- particularly in regard to providing meaningful uncertainty estimates attached to data, and ensuring consistency with historical in situ records.

The SST CCI project will generate a climate data record for SST from at least 1991 to 2010. This will be derived using physics-based optimal estimation methods, and will be independent of in situ observations. The satellite data for this "long-term" product will be from the Along Track Scanning Radiometers (ATSRs) and the Advanced Very High Resolution Radiometers (AVHRRs). In comparison with the well known Pathfinder AVHRR SST records, the SST CCI products aim to provide SSTs with lower regional biases (target 0.1 K compared to biases up to ~0.5 K in Pathfinder) with situation-specific uncertainty estimates attached to SSTs. This will be achieved by tying AVHRR records to ATSR and by improved approaches to retrieval

Both skin SST (to which satellites are directly sensitive) and depth SSTs will be estimated. Depth SSTs will be created from skin SSTs by model-based estimates for skin effect and depth-to-subskin stratification, an approach currently applied to ATSR with favourable results, which will be shown. Since the overpass time is highly variable for AVHRR observations, the model will also be used to adjust the depth SSTs in time to a common reference time (tentatively chosen to be 10.30 local solar time) in order to avoid alias of the diurnal cycle into the long-term record.

The approach to validation of the SST CCI products includes strict separation of in situ observations available to the algorithm development team and those available to the validation team (separated roles within the consortium). Selected "good" drifting buoys, Argo 4m SSTs, and radiometric SSTs will constitute the reference data for validation (each to be compared with the appropriate skin or depth SST).

The SST products will include a satellite-only spatially complete daily SST analysis, which again will be validated against completely independent in situ observations. Validation will include not only validation of SSTs, but validation of the associated uncertainties in SSTs.

Overall, the approach in the SST CCI is that satellite observations and in situ observations should be independent, and mutually exploited to gain the maximum understanding of different types of data.

Accurately measuring sea level change from space: an ESA Climate Change Initiative

G. Larnicol (CLS), Y. Faugere (CLS), M. Ablain (CLS) and A. Cazenave (LEGOS)

Sea level is an important climate variable and a major indicator of climate change. In effect, sea level integrates changes and interactions of all components of the climate system (ocean, atmosphere, cryosphere, hydrosphere); it varies globally and regionally in response to internal climate variability and external -including anthropogenic- forcing; sea level rise is one the most negative consequences of global warming. Sea level counts among the 50 Essential Climate Variables (ECVs) defined by the Global Climate Observing System for

climate change monitoring. Since about two decades, sea level is routinely measured from space using altimetry techniques. But to address the various topics relevant to sea level studies (how much is sea level rising? How unusual is current sea level rise? What are the causes of global mean sea level rise? What are the factors causing non uniform sea level change and how do corresponding spatial trend patterns evolve through time? Are climate models able to reproduce present and past sea level changes? What are the coastal impacts of sea level rise? etc.), space-based sea level measurements need to be as accurate as possible; which means understanding and reducing all sources of errors affecting altimetry-based sea level products. This is the main goal of the ESA CCI 'sea Level' project (composed of nine European partners plus a few selected international experts). Using multi-mission satellite altimetry data, the project proposes a new sea level ECV processing system, with dedicated algorithms and data processing strategies, for the generation of high-accuracy sea level products over the last two decades. The project includes validation/calibrations phases (including tide gauges comparison and sea level budget closure approach), and comparisons with climate models and ocean re-analyses products. The high-accuracy space-based sea level time series (global and regional) will complement historical tide gauge-based sea level, ensuring a high-quality climate record of very high value for climate studies.

ESA Ocean Colour CCI

Laurent Bertino ; Mohn-Sverdrup Center / NERSC

Understanding the structure and function of marine ecosystems requires a frequent and global observational coverage which is only possible through remote sensing. Ocean colour provides information on the distribution of marine phytoplankton at synoptic scales. Phytoplankton are key to life in the oceans, they are known to influence in a significant way two key aspects of all discussions on climate change – carbon cycle and heat budget – and we are still learning about other ways in which they influence our climate and our life. The general goal of the OC ECV CCI is "to realize the full potential of the long-term global ocean-colour archives that ESA together with its Member states have established over the last thirty years, as a significant and timely contribution to the ECV databases required by United Nations Framework Convention on Climate Change (UNFCCC)". The presentation will contain a general description of the project activities and focus on the EnKF approach chosen for assimilating the OC data into ocean biogeochemical models.

Climate relevant aerosol retrieval over ocean from the ESA aerosol_cci project

G. de Leeuw, T. Holzer-Popp, and the aerosol_cci team

Aerosols exert a perturbing influence on the observations of ocean parameters with electro-optical (EO) instruments such as those used from space to detect ocean colour, chlorophyll or sea-surface tmeperature. Therefore, the retrieval of such parameters requires the application of an atmospheric correction which accounts for aerosol effects. One of the goals of the ESA Climate Change Initiative project aerosol_cci is to provide the best possible global multi-year aerosol data set using data from several European Earth Observation sensors. This will be achieved through the preparation of consistent prototype aerosol retrieval algorithms. These prototype algorithms build on eight existing algorithms for ATSR, MERIS, SCIAMACHY, POLDER, OMI and GOMOS. An in-depth analysis and comparison of the retrieval results for a selected dataset and specific case studies has been started to better understand the strengths and weaknesses of each algorithm and the differences between the products. Information on best practices is exchanged and implemented to improve existing algorithms. Through inter-comparison and validation against other satellite and ground-based reference datasets, the reasons for differences between the algorithms are explored in detail. At the same time elements of community algorithms and harmonized retrieval are worked out. This analysis covers the different assumptions and algorithms on optical aerosol properties, surface reflectance / bi-directionality treatment and cloud masking as well as auxiliary datasets used.

The paper will provide an overview of the project work plan and summarize first results of the ongoing inter-comparison and evaluation work, with emphasis on the retrieval of aerosol properties over the oceans.

Critical Issues for the Specification of Unbiased and Homogeneous Marine Surface Wind Reanalyses

Cardone, V.J.[1]; Cox, A.T.[1]; Orelup, E.A.[1]; Swail, V.R.[2]
[1]Oceanweather Inc., UNITED STATES; [2]Environment Canada, CANADA

Up to about three decades ago the analysis of marine surface wind fields for real time and hindcasting purposes rested almost completely on how wind and sea level pressure observations from transient voluntary observing ships (VOS) were utilized in subjective or objective analysis schemes. Since then, the number of in-situ sources of synoptic wind measurements from moored and drifting buoys, automatic reporting shoreline stations and offshore platforms has grown steadily such that today they outnumber VOS by about a factor of two. This large temporal increase in spatial density, wide range of platform and sensor types, sampling and averaging intervals, measurement elevation, and bias toward coastal and shelf exposures all raise issues that, in some cases, have

been resistant to resolution. In this paper we focus on what we consider the most critical remaining issues, which include: (1) the accuracy of vertical wind speed profile models to raise (lower) buoy (platform) measurements from typically very low (very high) anemometer heights to reference height and stability; (2) possible wind speed biases associated with sea state induced buoy motion and/or sheltering, and (3) compatibility of different averaging intervals with those implied by NWP dynamical model grid-box temporal and spatial averages.

Within the past three decades, satellite remote of marine surface wind surrogates (microwave brightness temperature, backscatter) by active and passive microwave sensors have also proliferated, reaching a pinnacle, at least in the foreseeable future, during the ~10-year QuikSCAT mission. These data present their own unique challenges that arise mainly out of: differences in accuracy and dynamic range between passive and active systems, difference between C-band and Ku band active sensors, the asynoptic nature of the data, the attribution of elevation, thermal stratification, and averaging interval characteristics equivalent to in-situ estimates and effectiveness of data assimilation in an NWP center analysis/forecast cycle. The main issues raised and discussed with regard to remotely sensed marine surface winds in this presentation are: (1) while substantial homogenization projects have been recently completed or are in progress for remotely sensed variables such as SST and altimeter significant wave height, little effort of this nature has been applied to satellite wind speed, even for sensors of one type (e.g. SEASAT SASS, ADEOS NSCAT, ERS SCAT, QuikSCAT, ASCAT); (2) while it is well known that the Ku band sensors have a wider dynamic range than C band sensors, the differences have not been sufficiently defined, particularly in view of the emerging evidence that QuikSCAT sensed wind speeds up to ~45 m/s in rain-free extra tropical regimes (in so-called "winter hurricanes") are credible; (3) wide swath systems (e.g. QuikSCAT) can flood an NH ocean basin roughly twice per day at 12-hourly intervals, leaving the basin devoid of such measurements at other times, and NWP dynamical models are notoriously reluctant to assimilate surface winds to lasting effect.

Finally, we note that the most recent atmospheric reanalysis projects, such as the NOAA CFSR, have strived to assimilate all marine wind data sources, leaving none to evaluate the efficacy of the assimilation. We therefore recommend that the reanalysis projects be accompanied by a suite of sensitivity studies involving smaller historical periods to assess the incremental skill in accuracy of surface marine surface wind fields associated with each major data source.

Pathfinder, GHRSST, and the SST Essential Climate Variable Framework

Casey, K.S.[1]; Brandon, T.[1]; Evans, R.[2]
[1]NOAA National Oceanographic Data Center, UNITED STATES; [2]University of Miami, UNITED STATES

In the last view years, the sea surface temperature (SST) community has coalesced its thinking on the SST Essential Climate Variable (ECV) framework through the efforts of the Group for High Resolution SST (GHRSST) and the GCOS SST and Sea Ice Working Group. These efforts have resulted in an SST ECV product framework that consists of a three-dimensional array of related and coordinated products, each with different space-time, processing level, and SST-type characteristics. Taken together and visualized as a cube of related SST datasets, this framework is helping to optimize the distributed efforts of the international community. An overview of the SST ECV framework will be presented.

Contributing to this framework is the latest version of the Advanced Very High Resolution Radiometer (AVHRR) SST climate data record, known as Pathfinder Version 6. This latest version of Pathfinder will be presented in detail, with a focus on the improvements demonstrated over previous AVHRR SST datasets. Pathfinder's position in the SST ECV cube will be illustrated as will its conformance to the new Version 2 GHRSST Data Specification (GDS2), the community standard for satellite-based SST datasets. Comparison with other satellite and in situ based datasets will be presented along with a summary of future directions for the Pathfinder SST program.

Session C: Satellite and in situ datasets, reanalyses and analyses

A Collocation Service for *In Situ* and Remotely Sensed Measurements

Worley, S.J.[1]; Bingham, A.W.[2]
[1]NCAR, UNITED STATES; [2]PO.DAAC JPL NASA, UNITED STATES

Collocating remotely sensed and *in situ* marine surface measurements has the potential to support new data production and research opportunities. Comparing and contrasting these independent observing systems can reveal biases and systematic errors in both, which in turn would lead to improvements in retrieval algorithms and enhanced quality control. The research community will benefit not only from more accurate data products, but also the capability to combine these synergistic measurements for scientific analysis.

A web service system is a logical approach to this challenge. It can be built with scalable standard and open data access mechanisms, support automation and high frequency data transfers, and always provide data from the most current dataset versions. Collocated record pairs can be used for data evaluations by both the remote sensing and *in situ* measurement communities. A web service would also facilitate the development of third-party tools for correlating *in situ* and remotely sensed datasets.

Consider, for example, a web service attached to an *in situ* data archive and a web client at a satellite archive that is requesting and receiving collocated data pairs. In this case, satellite archive users could have immediate and easy access to complementary *in situ* data. The workflow could also be reversed, with a client at the *in situ* data archive requesting data from a web service at a satellite archive. Likewise, these data pairings could be used to improve the quality of the *in situ* dataset. Essentially, web services would provide precise selection of point data from multi-million record ocean datasets.

We will present a plan for an on-demand record collocation service. The framework will be described in terms of use case scenarios and how they suggest system requirements and potential elements in the exchange protocol. A phased implementation is likely to be used. The first, a research and development phase, will position JPL/NASA PO.DAAC as a client to an ICOADS web service at NCAR. There will be a software development activity, extensive testing to assure scalability and robustness, and finally an operational service between the two centers. The high volume automatic data systems will be supplemented with a GUI of small-scale user queries. In the second phase, PO.DAAC will establish a satellite data collocation web service and NCAR will be a client. The software applications supporting these two web services may require different IT approaches behind them, because the PO.DAAC has multiple collections with orders of magnitude more records than ICOADS. Offering these services to other users is the third phase; which could begin in parallel with the second phase. Other remote sensing data archives, *in situ* archives, and individual investigator teams are all potential users.

Importantly, our goal is to receive the critique and suggestions from the international community represented at MARCDAT-III. We hope to gain insight on how to further improve our requirements and plans so as to strengthen it and create a valuable service for both in situ and satellite research.

Satellite Data for Marine Climate Monitoring Purposes

Trentmann, J; Müller, R.W.; Fennig, K; Rosenhagen, G
German Weather Service (DWD), GERMANY

Satellite data over the oceans have, compared to in-situ data, the advantage of high homogeneity and dense spatial and temporal distribution. The two types of data complement one another in an ideal way. While data from ships and buoys are needed for the validation of satellite data, satellite data can be used to improve marine data. They provide climate information of global coverage over the oceans and are a good tool for the quality checking of in-situ data.

DWD hosts the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF) and is a global marine climatological data and monitoring centre. CM SAF generates, archives and distributes widely recognised high-quality satellite-derived products and services relevant for climate monitoring in an operational mode. All data are freely available in high temporal and spatial resolution at www.cmsaf.eu.

The paper presents an overview of the existing climate monitoring products of CM SAF and discusses potential applications for the integration of satellite datasets with in-situ observations. In particular, the development of a validation software for the collocation of satellite data with observations from buoys and ships will be presented.

Creating a Consistent Time Series of Global Sea-Surface Temperature using *in situ* and Satellite Data Sources

Kennedy, J[1]; Millington, S[2]; Smith, R[3]; Rayner, N[1]; Saunby, M[1]
[1]Met Office Hadley Centre, UNITED KINGDOM; [2]Met Office, UNITED KINGDOM; [3]Department of Marine Science, University of Otago, NEW ZEALAND

Sea-surface temperature measurements are made *in situ* by ships and buoys and from space by a variety of different satellite-based instruments such as the Advanced Very-High Resolution Radiometer (AVHRR) and the Along Track Scanning Radiometer (ATSR). These different platforms have very different error and sampling characteristics and so combining them to provide a homogeneous data set of sea-surface temperatures is problematic.

The ATSR instruments are characterised by high stability and low errors. By using a dual view geometry it is possible to detect and minimise the effects of aerosol in the atmosphere that might bias the measurements. The satellites that carry them are placed in orbits that do not drift significantly. However, the swath of the ATSR is relatively narrow.

In contrast the AVHRR instruments have a broad swath, but are more prone to biases associated with aerosol loading in the atmosphere. The NOAA satellites that carried the AVHRRs were placed in orbits that sometimes drifted significantly away from the original local equator crossing time.

By combining information from the ATSR instruments and estimates of aerosol loading from the TOMS (Total Ozone Mapping Spectrometer) data set, it was possible to adjust the AVHRR data to account for the effects of aerosol loading and orbital drift thus making use of the best aspects of both the ATSR and AVHRR instruments.

The adjusted series closely track *in situ* measurements that have been adjusted for the effects of instrument changes. A final adjustment step is performed that corrects for the remaining large scale differences between the analyses and the *in situ* and satellite data are then blended together based on a weighting of their individual errors.

Uses of Satellite Data for Gridded Sea Surface Temperature Analyses of Pre-Satellite Period

Kaplan, A
Columbia University, UNITED STATES

Many applications of climate data require gridded data sets of climate observations without spatial or temporal gaps. The content and uncertainty of such products depend on the error of individual observations as well as on the gridding technique. Optimal approaches to the gridding procedures make theoretical estimation of full uncertainty by far more expensive to compute and much more voluminous to report than the calculation of actual gridded fields. In fact, even error cross-covariance terms of state-of-the-art gridded products are never actually reported: only error standard deviations (and sometimes biases) of individual gridpoints are usually provided. Yet this limited information about uncertainty makes any accounting for it nearly impossible in most sophisticated research uses, e.g. spatial statistical analyses or forcing numerical models. Since the current methods of gridding and current applications of gridded sea surface temperature data sets are different for the satellite data era and for the period of sparse historical observations, the uncertainty representation must reflect these differences as well. These issues are illustrated by intercomparing historical data sets and satellite products for sea surface temperatures. Characterization of uncertainty by an ensemble representing a statistical error distribution in a gridded field is proposed as an adequate approach for the most sophisticated applications. Satellite-based sea surface temperatures are used in a triple way: for a better parameterization of sampling error of binned in situ data, for modeling mid-scale variability of sea surface temperature fields, and for representing uncertainty in the analyzed fields.

Improved Historical Reconstructions of SST and Marine Precipitation Variations

Smith, T[1]; Reynolds, R[2]; Arkin, P[3]; Banzon, V[2]
[1]NOAA/STAR, UNITED STATES; [2]NOAA, UNITED STATES; [3]CICS/ESSIC, Univ. Maryland, UNITED STATES

Historical reconstructions of marine climate variables employ satellite-based analyses to define statistics for analysis of more sparsely-sampled historical observations. Here improved methods for reconstruction of two climate variables are discussed. One variable is sea-surface temperature (SST), which is reconstructed from the middle of the 19th century. The other variable is precipitation, which is reconstructed from the beginning of the 20th century. Although there are similarities in the methods for each variable, the two are not analyzed using the same methods because of differences in sampling and variable characteristics.

Historical SST reconstructions have been successfully produced in the past. Improved methods discussed here are most important for the period before 1900 when data are sparser. The improved SST reconstructions better resolve spatial variations. Reconstruction of pre-satellite oceanic precipitation variations is more difficult because of the much sparser sampling available in the pre-satellite period. Improvements discussed here allow better resolution of multi-decadal precipitation variations compared to earlier analyses. Together these reconstructions provide data sets for evaluation of oceanic climate variations beginning 1900 or earlier.

The ERA-CLIM Project

Hersbach, H.; Dee, D.; Poli, P.
ECMWF, UNITED KINGDOM

ERA-CLIM is a joint project between the Met office Hadley Centre, Universitaet Wien, Universitaet Bern, Russian Research Institute for Hydrometerological Information World Data Center (RIHMI-WDC), Faculdade de Ciências da Universidade de Lisboa, Météo-France, European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), Dirección Meteorológica de Chile, and the European Centre for Medium-Range Weather Forecasts (ECMWF). It has recently been awarded a three year funding by the European Commission within the Seventh Framework Programme.

Coordinated by ECMWF, ERA-CLIM will develop observational datasets suitable for global climate studies, with a focus on the past 100 years. These datasets will include atmospheric, oceanic, and terrestrial observations from a variety of sources. Besides abundantly available satellite data for the last few decades, this includes data from existing archives such as the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) and the Integrated Surface Dataset (ISD).

In addition, ERA-CLIM will make a substantial contribution to filling known data gaps. Proposed data recovery efforts will focus on upper-air observations made in the first half of the 20th century, as well as near-surface observations of wind and humidity, in all regions of the globe.

A specific goal for the project is to improve the quality and consistency of climate observations through high-resolution global reanalyses. Such reanalyses provide a powerful tool to dynamically inter-validate observations from a variety of physical nature and origin, by using the laws of physics that relate them. The in this way obtained information, called analysis feedback, will be included in a newly developed Observation Feedback Archive, and will be made available to users world-wide as a unique resource for climate research and observational studies of the Earth system.

OSTIA Reanalysis: A high Resolution SST and Sea-Ice Reanalysis.

Roberts-Jones, J; Martin, M^2; Fiedler, E
UK Met Office, UNITED KINGDOM

A high resolution SST and sea-ice reanalysis has been produced using the Operational SST and sea Ice Analysis (OSTIA) system which runs at the UK Met Office. The output is a combined foundation SST and sea ice concentration product on a 1/20° (~6km) grid. The OSTIA reanalysis is a global, daily product of running from 1st Jan 1985 to 31st Dec 2007. Observational data sources used in the reanalysis are the AVHRR Pathfinder archive, (A)ATSR multi-mission archive, ICOADS in-situ archive and sea-ice data from the EUMETSAT OSI-SAF archive. Input data is passed through an automatic quality control system and a bias correction on selected satellites is carried out. OSTIA then uses a multi-scale optimal interpolation scheme to assimilate in-situ and satellite SST observations onto a first guess field provided by the previous analysis with a relaxation to climatology.

An overview of the OSTIA reanalysis system will be presented. Results of the assessment of version 1.0 of the OSTIA reanalysis will be shown including validation statistics, comparisons to other reanalysis products and to the operational OSTIA system where there is an overlap with the reanalysis period.

Satellite and In Situ Sea Surface Temperature Comparison and Merging in the Mediterranean Sea

Alvera-Azcarate, A.; Barth, A.; Beckers, J.-M.
University of Liege, BELGIUM

A comparison between in situ and satellite sea surface temperature (SST) for the western Mediterranean Sea is presented. Several international databases are used to extract in situ data: World Ocean Database (WOD), MEDAR/Medatlas, Coriolis Data Center, International Council for the Exploration of the Sea (ICES) and International Comprehensive Ocean-Atmosphere Data Set (ICOADS). The in situ data are classified into different platforms or sensors (CTD, XBT, drifters, bottles, ships), in order to assess the average difference

between these type of data and AVHRR (Advanced Very High Resolution Radiometer) SST satellite data. Attention is given also to the relative accuracy of each database, and advantages and shortcomings on the use of each database will be discussed. The error assessment will be used to merge in situ and satellite SST data using DINEOF (Data Interpolating Empirical Orthogonal Functions), an EOF-based technique. The impact of the sensor-specific errors on the quality of the final product will be assessed, and compared to the results obtained when a more general error estimate is used.

Session D: In situ datasets, reanalyses and analyses

All Historical SST Analyses are Wrong*, probably even this one

Kennedy, J
Met Office Hadley Centre, UNITED KINGDOM

Several long-term historical analyses of sea-surface temperature exist and they are widely used in climate science and related fields. The inter-analysis spread can be interpreted as a measure of structural uncertainty, but in order to fully span that uncertainty range, the analyses must take different approaches to all the problems associated with the analysis of SST.

Many studies have shown that there are significant biases associated with the methods used to measure sea-surface temperatures over the past 70 years and that these are manifested in global analyses of SST. They include: warm biases associated with measurements made in ships' engine rooms; cold biases associated with measurements made using insulated and uninsulated buckets; and the relative bias between ship and buoy measurements. The bias problem is compounded by rapid changes in measurement methods represented in the ICOADS data base, particularly at two points: the end of the Second World War, and the period since 1990 which saw the widespread proliferation of drifting buoys and a general decline in the number of ship-based observations.

These biases have not been addressed in existing analyses of historical sea-surface temperature therefore all existing analyses of historical sea-surface temperature are (probably) wrong* in their rendition of 20th century climate change.

In developing the HadSST3 data set we have attempted to quantify the biases and their likely uncertainties. At times, the median adjusted series lies outside the range of previous historical analyses and the estimated uncertainty arising from the bias adjustments is larger than the inter-analysis spread. Moreover, whenever other historical climate records have been homogenised - for example, radiosonde data, Microwave Sounding Unit data and sub-surface ocean data - no single analysis alone has managed to span the full range of the estimated uncertainty, thus implying that HadSST3 is likely to provide an underestimate of the true uncertainty.

Without multiple, independent attempts to homogenise the SST series, it is not possible to estimate the structural uncertainty and therefore the total uncertainty in SST data sets remains unknown.

**for a certain value of 'wrong'.*

A new Historical SST Analysis: COBE2-SST

Hirahara, S[1]; Fukuda, Y[1]; Ishii, M[2]
[1]Japan Meteorological Agency, JAPAN; [2]Meteorological Research Institute/JAMSTEC, JAPAN

We propose a new framework for the historical SST analysis. This analysis is a successor of COBE-SST (Ishii et al. 2005), and is referred to as COBE2-SST, here.

In the new framework, monthly mean SSTs are defined as an arithmetic average of daily SST analysis. The daily analysis is a combination of a trend, reconstructed 31-daily mean SST by using empirical orthogonal functions (EOFs), and an optimal interpolation (OI) analysis of day-to-day changes. The trend component is computed from an SST analysis on a coarse grid, beforehand. In addition, EOFs are calculated from a monthly OI SST analysis with satellite observations. The day-to-day analysis is conducted for SST differences from the daily components one day before the analysis date.

The use of the trend is equivalent to using time-varying climatology in the SST analysis. The SST analysis over data sparse regions benefits from the EOF reconstruction by adding the interannual variability. The day-to-day analysis produces more detailed SST variations in space and time, if observations are available there. Moreover, we will avoid criticisms such as statistically simple structures seen in a usual reconstruction analysis, by introducing the day-to-day analysis.

We also introduced an analysis error estimation in this framework.

Other changes in COBE2-SST will be discussed, as well.

A Hierarchical Bayesian Model for Ocean Properties Reconstructions

Sanso, B.[1]; Lemos, R.[2]
[1]University of California Santa Cruz, UNITED STATES; [2]NOAA/NMFS Environmental Research Division, UNITED STATES

We present HOMER: a Hierarchical Ocean Model for Extended Reconstructions. The goal is to obtain smooth three dimensional fields of temperature and salinity, as well as long term climatologies, on a monthly time scale. Using a hierarchical Bayesian model we are able to incorporate information from different sources and information about measurement error. We also impose constraints to avoid post hoc corrections. We use flexible compactly supported kernels to capture inhomogeneities in space. To deal with the heavy computations required to handle large geographical domains and long periods of time, we develop carefully designed Markov chain Monte Carlo methods using distributed computing.

Assessment and Validation of the NOCS2.0 Dataset

Berry, D. I.; Kent, E. C.
National Oceanography Centre, UNITED KINGDOM

Version 2 of the NOCS Surface Flux and Marine Meteorological Data Set (NOCS2.0) contains estimates of the surface meteorological parameters and fluxes over the oceans together with their uncertainty. This dataset has been constructed using an optimal interpolation (OI) scheme to gap fill and to estimate the uncertainty in the gridded fields together with observations from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). Daily mean fields of the meteorological parameters (and uncertainty) required for estimation of the surface fluxes are first estimated and then used to calculate the surface fluxes and flux uncertainty. The daily fields are then averaged to give monthly mean values.

In this presentation we first examine choices made in the development of NOCS2.0 and then assess the impact of those choices. The output fields from the OI will be shown to be unbiased with respect to the original observations and the dataset construction method shown to be unbiased through a series of independent cross validation experiments. The impact of the choice of length scales on the accuracy of the uncertainty estimates will also be shown. Finally, future developments for the dataset will be outlined.

Systematic Errors in the Hydrographic Data and their Effect on Global Heat Content Calculations

Gouretski, Viktor
University of Hamburg, GERMANY

Measurements by means of mechanical (MBT) and expendable (XBT) bathythermographs provided the majority of the subsurface temperature profiles in the global ocean since 1950s until the profiling floats have increasingly become the main data source in the beginning of 2000s. Both bathythermograph types were originally designed to provide data for military and operational applications and both are prone to systematic errors which are comparable in magnitude to decadal scale temperature variability in the global ocean. Neglecting these errors has lead to overestimation of the decadal variability in some earlier global heat content calculations. The more accurate CTD and bottle data from the World Ocean Database 2009 were used as an unbiased reference to estimate temperature and depth biases in MBT and XBT data. It is shown that the application of depth corrections estimated earlier from side-by-side XBT/CTD inter-comparisons, without accounting for a pure thermal bias, leads to an even larger disagreement with reference data. Our calculations suggest a depth-variable fall-rate correction with the original depths being overestimated in the upper 150-200m layer and underestimated below this depth. These results agree with side-by-side inter-comparisons, with direct fall-rate estimates, and are confirmed by a comparison of the XBT last sample depth with the bottom depth from the digital GEBCO depth database. Correcting XBT sample depths by a multiplicative factor which is constant with depth does not allow an effective estimation of the total temperature bias throughout the water column.

Comparison among different correction schemes shows a significant impact of systematic biases on the estimates of the global heat content anomaly. Using monthly temperature climatology based on CTD and Argo profiling float data for the period 1999-2008 we calculated global heat content anomaly time-series for the upper 20, 400 and 700 m which reveal a gradual warming of the upper World Ocean since 1990s, in a good agreement with independent time series based on a much larger sea-surface temperature ICOADS dataset. Application of the proposed corrections to the global XBT/MBT dataset reduces considerably the decadal-scale variability of the global ocean heat content. Uncertainties for the heat content anomaly estimates are also provided.

Ocean Heat Content Variations and its Trends estimated from Historical Oceanographic Observations.

Fukuda, Y[1]; Hirahara, S[1]; Ishii, M[2]
[1]Japan Meteorological Agency, JAPAN; [2]Japan Meteorological Agency/JAMSTEC, JAPAN

Quantifying the ocean heat content (OHC) is one of important bases for global and regional climate monitoring. However, it is hard to obtain accurate estimates because of sparse observations and historical changes in observational instruments. In recent years, it is pointed out that XBT and MBT observations have time-varying biases, although the biases and the correction method remain controversial.

Ishii and Kimoto (2009) conducted a global subsurface (0-700m) temperature analysis for recent 50 years. In the analysis, they corrected the XBT and MBT biases by comparing to nearby CTD observations. The biases were defined for each probe type as a linear function of the elapsed time from the instance when the probe touches sea surface. Moreover, it assumes that the biases have changed with the times. Applying this correction, the global mean OHC time-series shows signs of less decadal variations than that without the correction, although the OHC trend comparable between the two OHC time series.

The correction method will be introduced and OHC variations estimated will be presented. In addition to the global mean, we will discuss the regional OHC changes. After these introductions, we will discuss the uncertainty in the present OHC estimation on various spacio-temporal scales.

Session E: In situ data rescue

ACRE, Citizen Science and OldWeather

Allan, R; Brohan, P
Met Office, UNITED KINGDOM

The international Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative (http://www.met-acre.org/) is facilitating the development of comprehensive state-of-the-art historical weather reanalyses/reconstructions (http://reanalyses.org) for the international user community. These reanalyses depend heavily on historical marine observations, and a major focus of the work under ACRE is the recovery of additional historical weather observations from documentary sources.

The ship's logbooks of the British Royal Navy, maintained in the collection of The National Archives in the UK, provide a potential source of many millions of hitherto unused observations covering a wide area of the worlds oceans, over at least the last 300 years. The barrier to use of these records is the very labour-intensive process of reading the logs and keying the weather data they contain. To try and extract this data, ACRE has teamed up with the Citizen Science Alliance (http://www.citizensciencealliance.org/), which, under the umbrella of the Zooniverse (http://www.zooniverse.org), is pioneering the involvement of volunteers ('citizen scientists') in labour-intensive but scientifically important projects.

ACRE, The University of Oxford, The Met Office, Naval-History.Net, the UK National Maritime Museum, The National Archives in the UK, and the UK Joint Information Services Committee (JISC), have developed a pilot project, called Oldweather.org, to showcase the potential of using citizen science (http://www.oldweather.org/) to digitise large volumes of historical instrumental marine weather observations. For this pilot project, Oldweather.org is focusing on a batch of some 4,000 Royal Navy ship logbooks covering an extended World War 1 period (1914-1923), where existing observational coverage is particularly poor.

This presentation will show some of the results from Oldweather.org which demonstrate the potential of this citizen science approach, and also provide information about efforts to extend this work to other sources of historical climate data.

English East India Company Logbooks - Significant Contributions to History and Science

Freeman, E[1]; Ross, T[1]; Brohan, P[2]; Wilkinson, C[3]
[1]NOAA/NCDC/STG, Inc., UNITED STATES; [2]Met Office Hadley Centre, UNITED KINGDOM; CRU/Univ. East Anglia, UNITED KINGDOM

Since 2008, a digitization project has been underway to extract instrumental observations of barometric pressure and air temperatures, among other elements, from nearly 900 original English East India Company (EEIC) logbooks archived at the United Kingdom's British Library. Through many partnerships, the logbooks have been imaged and keyed into digital form in order to permanently preserve their contents and make the logs easily accessible for generations to come. These logs provide a wide coverage of observations in the Atlantic and Indian Oceans during 1788-1834, a period where existing collections of marine instrumental weather data are very limited. This collection will support regional and global climate research and reanalysis efforts back to the late 18th Century and will provide valuable clues of the earth's climate during that period. By making the digital images available to the public, the contents of the logbooks can also be more easily examined by scientists as well as other disciplines outside of the climate community.

This talk will focus on the official release date of the full collection of digitized instrumental observations as well as permanent archive locations and access to the logbook images and digital data. Preliminary analysis results of the surface meteorological data extracted from the logs will also be presented.

International Marine Data Rescue The RECovery of Logbooks And International Marine Data (RECLAIM) Project

Wilkinson, C[1]; Woodruff, S[2]; Freeman, E[3]
[1]CRU/Univ. East Anglia, UNITED KINGDOM; [2]NOAA Earth System Research Laboratory, UNITED STATES; [3]NOAA/NCDC/STG, Inc., UNITED STATES

The RECovery of Logbooks And International Marine data (RECLAIM) project is a concerted, international effort to facilitate and encourage the recovery-through imaging and digitisation-of archived marine weather observations, platform and instrumental metadata, and historical documentation, from many different countries.

Non-instrumental observations of wind and weather have been recorded in ships' logbooks for hundreds of years, augmented by systematic instrumental observations of sea surface and air temperatures, barometric pressure, and other meteorological (and oceanographic) elements largely since the mid-19th century. Once digitised, these data are widely useful for climate studies and other avenues of scientific research-including oceanography, fisheries, maritime history and ecology-thus improvements seeking to address gaps and weaknesses in the currently available data record can be of major importance. Since the project inception in 2005, RECLAIM has facilitated for example recovery of logbooks of the Dutch and English East India Companies in the 19th century, and of the British Royal Navy of the 20th century. Other international projects are developing that include Chilean marine archives and US historical records.

This talk will focus on the importance of documenting the marine meteorological and oceanographic content of national and regional archives around the world.

Rescue of Historical Records of the US Fish Commission and the US Navy

Marzin, C
NOAA ONMS, UNITED STATES

For the past several years, the Office of the National Marine Sanctuaries (ONMS) has undertaken a comprehensive effort to rescue historical documents of the US Fish Commission, the predecessor to NOAA's National Marine Fisheries Service. For ONMS, historical analyses have great implications for management of marine protected areas by expanding the overall understanding of what marine ecosystems used to be and how they function. The mission of the marine sanctuaries is to serve as trustee for the nation's system of marine protected areas, to conserve, protect, and enhance their biodiversity, ecological integrity and cultural legacy. In order to succeed in its mission, and set realistic restoration targets, it is imperative that sanctuary managers have a long term perspective on what brought the ecosystem to its current states, so that they can better plan for the future.

Working in partnership with NOAA's Earth Systems Research Laboratory (ESRL) and the Climate Data Modernization Program (CDMP), ONMS is imaging historical scientific logbooks of the US Fish Commission's fisheries research vessels and keying their geo-referenced data. In addition to ecological information, these documents contain climate data that will be included into ICOADS. Because some of the fisheries research vessels were commissioned by the US Navy during wars, their decklogs, which contain geo-referenced atmospheric information, were included in the naval collection of the National Archives.

The talk will present progress on this work as well as on a new initiative to access the wealth of climate data contained in deck logs of US Navy ships.

Session F: Land-marine: cross-cutting data and analyses

Land Surface Temperature Records - are we keeping our Side of the Bargain?

Thorne, P
NCSU, UNITED STATES

Over the past three decades there has been intensive effort by the marine climate community to collect, collate, and understand the historical marine data and its implications for our understanding of climate change. Arguably there has been no commensurate internationally coordinated effort on the in-situ land record side. Recognizing the need to create products that are useful for envisaged 21st Century societal and scientific needs a workshop was recently held at the UK Met Office to instigate such an effort, starting with temperature records. In this talk I will highlight agreed outcomes of the workshop and briefly update upon incipient steps to make this a reality. This ambitious program includes an end-to-end process which will form the majority of my talk:

1. Creating a single go-to databank for land meteorological observations similar to ICOADS and working with ICOADS to ensure that they interface. Particular attention needs to be given to provenance and version control.

2. Promoting the production of numerous independent reconstructions of land surface temperature records. These could be global or regional and monthly, daily or sub-daily resolution.

3. A consistent methodological benchmarking exercise overseen by a dedicated benchmarking group. This benchmarking would be cyclical and involve the dataset creators. It is envisaged that actual analogs on which to test the algorithms would be provided by a third party to ensure a double blind assessment.

4. Serving of data products, metadata, visualization capabilities and value added products through a single location to aid users.

It is clearly important that this effort does not evolve in isolation from the marine community. We have a lot to learn from what the marine community have already achieved. It is also certainly true that many users want to consider the entire globe rather than the land or marine components in isolation. It is important that we work to together to make this as easy as possible. So, the talk will finish with some personal thoughts on how to make this possible.

Further information can be found at www.surfacetemperatures.org and http://surfacetemperatures.blogspot.com/.

Is it Good Enough? Benchmarking Homogenisation Algorithms and Cross-Cutting with Efforts for Land Observations

Willett, K
UK Met Office, UNITED KINGDOM

The 21st Century requirements on Climate Science call for finer temporal and spatial resolution. In turn this significantly enhances the need for long term, widespread observational datasets that are robust to varying non-climatic influences over time because smaller scales decrease the mediating effect of averaging on systematic biases and random errors. While we can never restore the data to ground truth, we can improve our understanding of the strengths and weaknesses of our many methodologies and it is essential that we do so. Benchmarking our homogenisation algorithms against a known reference will improve our understanding and quantification of uncertainty. It also allows some meaningful intercomparison of methodologically independent datasets - where by the nature of their methodological choices, some will be more suited to certain applications than others.

We are investigating a more involved benchmarking than has been undertaken previously - utilising spatially complete GCM data downscaled to match real observing network characteristics (climatology, variance, autocorrelation with neighbouring stations). This gives us a known 'truth' to which a number of 'pseudo-worlds' of likely random and systematic errors can be added. It allows us to test each homogenisation method by comparing the resulting trends, mean state and other characteristics to the known 'truth' and quantify the percentage of detection and false alarm rates.

Efforts towards this are underway in the land community but much can be learned from and shared with those working on marine data. This will help to further unite the marine and land communities of data-product creators.

Changes in Cloud Cover and Cloud Types over the Ocean from Surface Observations, 1954-2008.

Eastman, R. M.[1]; Warren, S. G.[1]; Hahn, C. J.[2]
[1]University of Washington, UNITED STATES; [2]University of Arizona, UNITED STATES

Synoptic weather observations from ships throughout the world ocean have been analyzed to produce a climatology of total cloud cover and the amounts of nine cloud types. About 54 million observations contributed to the climatology, which now covers 55 years, from 1954 to 2008. In this work seasonal cloud amounts are analyzed in 10-degree grid boxes for interannual variations and trends. Long-term variations, coherent across multiple latitude bands, remain present in the updated cloud data. The variations are shown to likely be spurious when a comparison is made to coincident data on islands. An exact cause for this behaviour remains elusive. The globally-coherent variations are removed from the grid-box time series in the form of a polynomial before analysis for trends and correlations.

The global average time series of total cloud cover over the ocean shows low-amplitude, long-term variations on the order of 2 percent over the 55-year period. High-frequency, year-to-year variation is seen on the order of 1-2%. Predicted trends in zonal average cloud cover may be substantiated with observed decreases in total cloud cover at mid-latitudes and an increase in low clouds near the north pole.

Among the cloud types, the most widespread and consistent relationship is found for the extensive marine stratus and stratocumulus clouds (MSC) over the eastern parts of the subtropical oceans, both in their correlations with sea-surface temperature (SST) and their trend with global temperature changes. Affirming previous work, strong negative correlation is found between MSC and SST in the eastern north Pacific, eastern south Pacific, eastern south Atlantic, eastern north Atlantic, and the Indian Ocean west of Australia. A positive correlation between cloud cover and SST is seen in the central Pacific. High clouds show a consistent low-magnitude positive correlation with SST over the equatorial ocean.

In regions of persistent MSC, there has been a trend of decreasing MSC amount. Combined with the negative correlation between marine stratus and sea surface temperature, a positive cloud feedback to a warming sea surface is suggested. The decrease of MSC has been partly offset by increasing cumuliform clouds in these regions; a similar decrease in stratiform and increase in cumuliform clouds had previously been seen over land.

Interannual variations of cloud cover in the tropics show strong correlation with an ENSO index, though trends in ENSO do not explain an increase in cloud cover over the central equatorial Pacific.

Estimating Long Term Trends of ENSO Variability

Chiodi, A. M.[1]; Harrison, D. E.[2]
[1]JISAO/University of Washington, UNITED STATES; [2]NOAA/PMEL, UNITED STATES

The task of identifying which aspects of climate are undergoing very long term trends has received increased attention in recent decades. Historical records of marine climate have and will continue to be key to this task, but because observing long term trends was not a goal of most of our observing activities until recently, it is challenging to find appropriate high quality observational records for this task. We here use a high quality, century-length (135yr) record, that of sea level pressure at Darwin, Australia, which is a very good proxy for the state of the El Nino-Southern Oscillation phenomenon, to illustrate some of the issues faced in such trend studies, and identify some of the qualities required from a historical record to yield reliable trend estimates.

Because geophysical spectra tend to have considerable variance at low frequencies (they are("red") and often are also energetic at much shorter frequencies, it can be challenging to make reliable estimates of long term trends, even from multi-decadal time series. We suggest that this discussion is timely and relevant in part because a decade ago there was a vigorous scientific discussion about whether there is a long term trend in ENSO and the topic has not been revisited for some time. Further, a trend in ENSO would have significant environmental consequences for many regions of the planet and IPCC models differ in their predictions about ENSO trends.

We examine trends in this long record in several ways. We consider long (> 90 years) segments and shorter multi-decadal segments typical of the recent era in which improvements to the ocean observing system (e.g. increased numbers of in situ measurements post-WWII, and the use of satellite information in more recent decades) have contributed importantly to our observational knowledge of the planet, using both the familiar Student's test and bootstrap/Monte Carlo tests for trend statistical significance. We find that the distribution of multi-decadal trends includes nearly equal numbers of positive and negative trends, and some of these pass both "t" and bootstrap tests of significance. This is not a useful length of record for estimating long term trends for this quantity. Over the full record, there is no statistically significant trend at the 95% level. For ENSO, given only a single multi-decadal record, one would be very unlikely to be able to estimate the long term trend.

Session G: In situ and satellite wave data

Wave Measurement Evaluation and Testing

Swail, V[1]; Lee, B[2]
[1]Environment Canada, CANADA; [2]Intergovernmental Oceanographic Commission of UNESCO, FRANCE

The JCOMM Expert Team on Wind Waves and Storm Surges (ETWS) is presently carrying out a Pilot Project (www.jcomm.info/WET) for the Data Buoy Cooperation Panel to address potential biases in in-situ wave measurements from buoys. Comparisons with satellite altimeter data suggest that there are significant biases between operational buoy networks operated by different national agencies, even with the same platforms. Biases are a serious concern in climatology, especially in computation of trends, but are also relevant for example in comparisons of wave model performance and regional statistics. Such biases would be important to consider in ICOADS wave summaries.

This presentation will describe the requirements for, and implementation of a continuous wave measurement testing and evaluation program for existing moored buoy networks and possible extension to future in situ and remotely sensed wave observation programs. We will describe the intercomparison methodology for evaluating co-located wave measurements, including details of the so-called "First-5" approach, the web site and interface established to coordinate and document the various intercomparisons carried out by the project participants, the metadata requirements for intercomparisons and for operational networks, recommended quality control procedures for wave data, and protocols for field tests of wave measurement systems, including how the first set of system tests will be conducted, and how results will be presented. Examples of the first sets of intercomparisons carried out will also be presented.

Project GlobWave

Busswell, G.[1]; Piolle, J-F.[2]; Ash, E.[3]; Collard, F.[4]; Snaith, H.[5]; Poulter, D.[5]; Pinnock, S.[6]
[1]Logica, UNITED KINGDOM; [2]Ifremer, FRANCE; [3]Satellite Oceanographic Consultants, UNITED KINGDOM; [4]Collecte Localisation Satellites, FRANCE; [5]National Oceanography Centre, UNITED KINGDOM; [6]ESA/ESRIN, ITALY

The ESA GlobWave project is a three year initiative, funded by ESA and CNES, to service the needs of satellite wave product users across the globe. Led by Logica UK, with support from CLS, IFREMER, SatOC and NOCS, the project will provide free access to satellite wave data and products in a common format with consistent error characterisation, both historical and in near real time, from various European and American SAR and altimeter missions. Level-2-Preprocessd wave products will be available from ERS-1, ERS-2, Envisat, Topex/POSEIDON, Jason-1, Jason-2, US Navy GEOSAT and US Navy/NOAA GEOSAT Follow On. SAR Level-2-Preprocessed wave products will be available from ERS-1, ERS-2 and Envisat. The full historical archive from each satellite will be made available. Near real-time data will be provided within 1 hour of us receiving the data from the relevant agency. Building on the successes of similar projects for Sea Surface Temperature and ocean colour, the project aims to stimulate increased use and analysis of satellite wave products. In addition to common-format satellite data the project will provide comparisons with in situ measurements, interactive data analysis tools and a pilot spatial wave forecast verification scheme for operational forecast production centres. The project began operations in January 2009 with direction from regular structured user consultation. The main outputs from the GlobWave project will be:

1) A portal (http://www.globwave.info) as the single point of contact for satellite wave data, cal/val information and integrated online diagnostic tools.
2) Handbook for new users providing information on the various types of satellite wave data and how to access and utilise them.
3) Inter-comparison of different satellite wave data sources.
4) Cross characterisation of different SAR and altimeter wave data with collocated in-situ measurements.
5) A uniform, harmonised, quality controlled, multi-sensor set of satellite wave data and ancillary information in a common format, with consistent characterisation of errors and biases.
6) The demonstration of new types of satellite wave data products, such as those based on new retrieval techniques, new types of satellite data, merged data from different sensors, or combinations of model and satellite data.
7)Develop and trial a pilot facility, following JCOMM recommendations, to permit participating operational agencies to routinely spatially inter-compare their wave models with each other, and with satellite wave data.

Global Ocean Wind Waves from ICOADS during the last 130 Years: Reliability, Extremes and Climate Variability

Grigorieva, Victoria; Gulev, Sergey
P.P. Shirshov Institute of Oceanology, RAS, RUSSIAN FEDERATION

We analyse visual wind wave estimates from the ICOADS collection of Voluntary Observing Ship (VOS) reports for the period 1880 onwards. Along with the model wave hindcasts and satellite data visual waves from VOS represent an important source of global wave information, which allows for the analysis of waves for centennial period. We present the methodology for the pre-processing of the VOS wave reports and provide assessment of all types of errors and uncertainties in the VOS wave data. Using corrected wind wave parameters we developed global climatology of wind waves covering the period from 1880 to 2008. Two streams cover the period prior 1960 (when only the highest of sea and swell were reported) and from 1960 (when all wave parameters, including separate estimates of heights, periods and directions of wind sea and swell were available). For the first time all climatological estimates of wave characteristics are derived for the waves of different directions that allows for accurate analysis of different wave systems in different regions. The same directional approach was applied for the derivation of extreme wave statistics including top percentiles and return periods derived from both initial value distributions and extreme value distributions of wave characteristics. Separate analysis was performed for the geometry of extreme waves. There is an evidence that extreme wave tended to increase in height during the last decades and also became more steep, implying higher relative pace of growing height compared to the length. These signals were accurately quantified for the North Atlantic and North Pacific as well as for some other areas where with well sampled ship routes.

The Effects of Changes in Observational Practices for Moored Buoys on Long Term Wave Trend

Thomas, B; Swail, Val
Environment Canada, CANADA

We assess the effects of changes in observational practices for moored buoys such as buoy type, platform type and size, wave processor, and wave sensor type on computation of long term wave trends. Such changes can affect the wave trend by introducing non-climatic step changes into the wave record. Relatively long-term wave measurements along the northeast Pacific and northwest Atlantic continental shelves began in the 1970s at a number of locations, and in the 1980s in many more locations as the US and Canadian weather buoy networks were developed. At a few locations in Canadian coastal waters, in both shallow and deep water, the deployment of weather buoys was preceded by the deployment of Datawell Waveriders. Combining these records allows the creation of a longer term record but may introduce step changes. After gathering metadata information about buoy observational changes and detailed quality control for each station, we create monthly means for significant wave height. We detect inhomogeneities in the long term record of monthly means using a proven statistical software program called RHTest. The sensitivity and reliability of the test is improved through use of a homogeneous reference time series of hindcast wave heights at each location. The software also allows for the time series to be adjusted, in order to correct for these step changes, where they are determined to be significant. We compare the long term trends at a number of locations on each coast before and after adjustment for buoy observational changes.

Comparing Significant Wave Height Statistics from ICOADS and Satellite Altimeter Data

Rutherford, M.J
Royal Australian Navy, AUSTRALIA

A comparison of wave statistics derived from ICOADS marine observations and significant wave height data from altimeters is currently underway.

The data sources, quality control and processing techniques will be discussed. Preliminary results are also expected to be available and will be presented.

Session H: In situ marine data management initiatives

Status and Plans for the International Comprehensive Ocean-Atmosphere Data Set (ICOADS)

Woodruff, S
NOAA Earth System Research Laboratory, UNITED STATES

The International Comprehensive Ocean-Atmosphere Data Set (ICOADS) is the most complete and extensive archive available of in situ marine meteorological observations-presently covering 1662-2007 (at Release 2.5), and augmented by "preliminary" extensions lagging one month behind real-time. Plans will be described for another major historical update around 2012 to support reanalyses, as well as a range of other critical research applications (e.g. improved temperature and pressure analyses).

Historical records rescued through ACRE, CDMP, and affiliated projects-including RECovery of Logbooks And International Marine data (RECLAIM)-will continue to enrich spatial and temporal coverage, and provide improved platform and instrumental metadata. Contemporary ship, buoy, and other records will also benefit from planned improvements including the use of higher quality and more complete delayed-mode archives, and through populating the International Maritime Meteorological Archive (IMMA) observational format with additional metadata, and ultimately feedback metadata from both operational and reanalysis models.

In the longer-term, resources are being sought to produce an improved version of ICOADS, utilizing community input. Experts have done significant work on specific variables and periods to enhance homogeneity across observing systems, quantify the estimated uncertainties, and improve quality control. Presently however, the results of these community efforts are not easily traceable back to the original observations, so the broader community cannot easily benefit from these improved observations. This project will address this barrier by (a) establishing an ICOADS Value-Added Database (IVAD) to support the development and user access; (b) extending the IMMA format to improve the tracking of data provenance, and hold new parameter adjustments, and essential metadata; and (c) scientifically demonstrate the impact of the value-added records on air-sea flux estimates and common climate indicator series.

Developing an ICOADS Value-added Database to Support Climate Research

Smith, S.[1]; Bourassa, M.[2]; Woodruff, S.[3]; Worley, S.[4]; Kent, E.[5]; Josey, S.[5]; Rayner, N.[6]; Freeman, E.[7]
[1]Florida State University, UNITED STATES; [2]Center for Ocean-Atmospheric Prediction Studies, UNITED STATES; [3]NOAA/ESRL, UNITED STATES; [4]National Center for Atmospheric Research, UNITED STATES; [5]NOC-Southampton, UNITED KINGDOM; [6]Met Office Hadley Centre, UNITED KINGDOM; [7]NOAA/NCDC/STG, Inc., UNITED STATES

The international marine climate community has proposed a program to create an "advanced" version of the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). ICOADS is the most complete and extensive archive available of historical in situ surface marine meteorological observations-presently covering 1662-2007, and augmented by "preliminary" near-real-time extensions lagging about one month behind real-time. Researchers have taken the ICOADS observed records and applied bias adjustments for various instruments and observing techniques, improved estimations of uncertainties, and advanced quality control (QC) to typically create global, gridded products of marine Global Climate Observing System (GCOS) Essential Climate Variables (ECVs). These products are essential for climate research. Making such adjustments and additional information freely available alongside the observed records would have clear benefits for climate researchers and dataset developers alike. The proposed international program would address this opportunity and scientifically demonstrate the impact through a new ICOADS "Value-Added Database"(IVAD).

As a result of ongoing international discussions, the authors envision a group of active researchers with experience using ICOADS assuming responsibility for making data adjustments, metadata, and other derived information available alongside the original data records, which will remain unaltered. Proposed contributions would be vetted by a coordination group, and a unified interface would inform the users about the latest updates, and provide flexible data access and documentation. The proposed system would be dynamic and evolve as recommended adjustments are evaluated, reviewed, and refined. The resulting IVAD would support a new broad set of global and regional gridded ECV products and provide a foundation for enhanced marine climate summary statistics.

The authors will provide a status report on IVAD development. Within the United States marine climate community, resources are being sought from NOAA to confront the complex obstacles associated with our current inability to trace the value-added improvements back to individual ICOADS observations. We will describe the goals of this effort which include (a) establishing a database management system (DBMS) to support the development of value-added records and access service for users; (b) implementing modifications to an internationally recognized data archive format to expand the capabilities for records tracking, data provenance documentation, and inclusion of fields to hold new parameter adjustments and essential metadata; and (c) scientifically demonstrating the impact of value-added records on air-sea flux estimates and common climate indicator series. The authors will also address a recommendation by the Expert Team on Marine

Climatology to establish a JCOMM[1] pilot project to foster IVAD development and clear parallels of this effort with new activities within the land surface climate community.

[1]JCOMM is the Joint World Meteorological Organization (WMO)/Intergovernmental Oceanographic Commission (IOC) Technical Commission for Oceanography and Marine Meteorology.

Improving VOS Data Management: An Update on Progress from JCOMM Task Team on Delayed Mode VOS Data

Scott, Nicky
Met Office, UNITED KINGDOM

The Marine Climatological Summaries Scheme (MCSS) was first proposed at the third session of WMO Commission on Marine Meteorology in 1960, and eventually adopted at the fourth congress in 1963. The objective was to establish a joint effort of all maritime nations in the preparation and publication of climatological statistics and charts for the oceans. Eight countries each with a specific ocean area of responsibility were designated to process the data in prescribed forms and regularly publish climatological summaries. In 1993, to help improve flow and quality control of global data, two Global Collecting Centres (GCCs) were established - one in the UK and one in Germany. For each area of responsibility, monthly, annual and decadal summaries were to be produced in either chart or tabular form. The summaries would provide up to three pieces of information for a given element (i.e. for air temperature, mean, standard deviation and number of obs may be displayed) for a sample area of ocean.

In 2004 a questionnaire was produced and circulated among WMO members involved in marine climatology to determine members' opinions on the MCSS. The results confirmed the need for change and in 2007 the DMCG-II and ETMC-II appointed two task teams to work on bringing data processing, quality management and storage up-to-date and to align the output climatologies with modern user requirements. Since then the task team on Delayed Mode VOS Data (TT-DMVOS) and the task team on Marine Meteorological & Oceanographic Climatological Summaries (TT-MOCS) have been working towards the modernisation of MCSS.

The tasks identified to address are:

- ☐ Improved VOS data flow structure
- ☐ Development of a more detailed Higher Quality Control Standard for archiving purposes
- ☐ Revision of IMMT-3/MQCS-5
- ☐ Proposal of a flexible future delayed mode VOS data format
- ☐ Identification and utilisation of a central, easily accessible data storage point
- ☐ GCCs to be proactive in data collection
- ☐ Identification of true MCSS contributing member states
- ☐ Modernisation of climate products (in co-operation with TT-MOCS)

There has been good progress made on these tasks by TT-DMVOS and the wider VOS community. A detailed update on work done and future plans and timescales will be presented at MARDAT-III.

Session D: In situ datasets, reanalyses and analyses (continued)

Reconstruction of Centennial Time Series of the North Atlantic Surface Fluxes from VOS

Gulev, S.K.
IORAS, RUSSIAN FEDERATION

Temporal and spatial inhomogeneity of sampling is critical for the accurate estimation of climatological surface fluxes and assessing their climate variability and change. Time dependent sampling biases prevent efficient use of the VOS data for estimation of climate variability in key variables and especially in the VOS-derived air-sea fluxes which are critically sensitive to sampling uncertainties since require multiply state variables for computations. In order to derive long-term time series of surface turbulent heat fluxes in the North Atlantic we used VOS data from ICOADS collection for the period from 1880 to 2008 and applied a statistical methodology to produce homogenized time series for the mid latitudinal North Atlantic. The methodology involves homogenization of sampling by the random sub-sampling of original data using a fixed number of samples and a simple parameterization of relative humidity which is practically unavailable before the decade of 1910s. These and some other procedures were applied to the fluxes computed from individual VOS reports. Obtained 130-yr time series for the North Atlantic are analysed with a focus on linear trends, interannual variability and connection to the variability of the North Atlantic SST. Long-term time series allowed for the discrimination of mechanisms responsible for the links between surface fluxes and SST at different time scales. On long-term time scales (multidecadal) correlation between the reconstructed surface fluxes and SST in the North Atlantic mid latitudes is significantly positive, while it may become negative on short-term time scales. Regional manifestations of this effect are discussed.

Poster Session

Theme 1

A Comparison of Surface Wind Speed Datasets

Kent, E. C.[1]; Fangohr, S.[2]; Berry, D. I.[1]
[1]National Oceanography Centre, UNITED KINGDOM; [2]University of Southampton, UNITED KINGDOM

Marine wind speed is an important physical parameter, driving the air-sea exchange of heat, water, momentum, gases and aerosols. In the context of determining the monthly mean air-sea heat fluxes it has been estimated that an accuracy of 0.2 ms^{-1} is required in order to estimate the net heat flux to an accuracy of 10 Wm^{-2}. In this presentation several datasets of monthly mean wind speed data are compared in an attempt to determine whether any available wind speed data source meets the accuracy requirements for surface heat flux calculation. It should be noted that meeting this accuracy requirement in the monthly mean, although a necessary condition, does not guarantee that heat fluxes can be calculated to this accuracy. In addition the dataset must also meet further requirements relating to variability, but these requirements are currently less well defined.

The analysis shown compares wind speed data from a variety of sources: in situ; reanalysis; satellite scatterometer and passive microwave; and also blended datasets combining a variety of different data sources. Some of the datasets are presented as neutral wind speeds, some as stability-dependent values. There is uncertainty involved in adjusting between neutral and stability-dependent winds which has led to some researchers either neglecting the differences, or applying a constant offset. We show that the spatial and temporal variability in the adjustment is likely to be larger than the uncertainty in making the adjustment.

Differences between the datasets are shown to depend on rainfall and distance from the coast. Surface currents are a further source of differences but are thought to have a smaller impact - any future availability of high-resolution surface current estimates will allow their effects to be more accurately determined. After adjustment for the effects of stability, the mean differences between datasets are typically larger than the target accuracy of 0.2 ms^{-1} over large regions. Some differences can be attributed to biases in particular datasets or measurement methods, but the remaining differences mean that the surface heat flux cannot be determined to better than 10 Wm^{-2} with confidence due to uncertainty in mean wind speed on monthly timescales.

(A)ATSR Re-Analysis for Climate (ARC): Stability of ATSR Data Versus *in situ* Observations

Berry, D. I.[1]; Kent, E. C.[1]; Merchant, C. J.[2]; Embury, O.[2]
[1]National Oceanography Centre, UNITED KINGDOM; [2]University of Edinburgh, UNITED KINGDOM

Sea surface temperature estimates from the Along Track Scanning Radiometer series of satellites (ATSR, ATSR-2 and AATSR) have recently been re-analysed for climate studies as part of the ARC project. The aims of this project were to create a homogenized dataset with high accuracy and stability requirements. In this poster we examine the effectiveness of the homogenization by comparison of the ATSR data with *in situ* observations, looking for step changes in the overlap periods and residual drift in the individual satellite records. The error characteristics of the *in situ* and satellite data will be examined and the sensitivity of the tests to detect residual offsets and drift presented.

Quantifying Variance Due to Temporal and Spatial Difference between Ship and Satellite Winds

Bourassa, M.A.; May, J.; Smith, S.R.
Florida State University, UNITED STATES

Ocean vector winds measured by the SeaWinds scatterometer onboard the QuikSCAT satellite can be validated with in situ data. Ideally the comparison in situ data would be collocated in both time and space to the satellite overpass; however, this is rarely the case because of the time sampling interval of the in situ data and the sparseness of data. To compensate for the lack of ideal collocations, in situ data that are within a certain time and space range of the satellite overpass are used for comparisons. To determine the total amount of random observational error, additional uncertainty from the temporal and spatial difference must be considered along with the uncertainty associated with the data sets. The purpose of this study is to quantify the amount of error associated with the two data sets, as well as the amount of error associated with the temporal and/or spatial difference between two observations.

The variance associated with a temporal difference between two observations is initially examined in an idealized case that includes only Shipboard Automated Meteorological and Oceanographic System (SAMOS) one-minute data. Temporal differences can be translated into spatial differences by using Taylor's hypothesis. The results show that as the time difference increases, the amount of variance increases. Higher wind speeds are also associated with a larger amount of variance. Collocated SeaWinds and SAMOS observations are used to determine the total variance associated with a temporal (equivalent) difference from 0 to 60 minutes. If the combined temporal and spatial difference is less than 25 minutes (equivalent), the variance associated with the temporal and spatial difference is offset by the observational errors, which are approximately 1.5 m2s-2 for wind speeds between 4 and 7 ms-1 and approximately 1.0 m2s-2 for wind speeds between 7 and 12 ms-1. If the combined temporal and spatial difference is greater than 25 minutes (equivalent), then the variance associated with the temporal and spatial difference is no longer offset by the variance associated with observational error in the data sets; therefore, the total variance gradually increases as the time difference increases.

Remotely Sensed Surface Turbulent Fluxes and Validation with In Situ Observations

Bourassa, M.A.
Florida State University, UNITED STATES

Historical challenges in observing air-sea fluxes include insufficient sampling, biases, large random errors in air temperature, and no accounting for how surface water waves modify fluxes. There have recently been tremendous improvements in the accuracy of satellite retrievals of near surface (a height of 10m) air temperature and humidity, which are used in bulk parameterizations of surface turbulent fluxes. These retrievals have been based on SSM/I observations of radiances and validated with in situ observations. These observations can be input into a bulk algorithm to determine surface turbulent heat fluxes.

It is also anticipated that the retrieval of stress, rather than wind, will further reduce errors in satellite derived turbulent fluxes. Scatterometers have been shown to respond to surface stress rather than wind. This has several advantages to the calculation of surface turbulent heat fluxes. The key advantage is that the high controversial wave influences impact the stress, and hence the friction velocity, drag coefficient, and momentum roughness length. These modify the turbulent transfer of heat and moisture. Therefore, the stress observations can be used to remove regional and seasonal biases, as well as spurious variability associated with the synoptic pattern.

Surface turbulent stress, as inferred by wind speed, has been shown (Kara et al. 2007) to be modified by swell (surface water waves generated by distant storms). For the published example for 0Z on January 1, 2005, the change in wind shear (U10 – Usfc) was modified by from -15% to +10%, and the monthly average was changed by from -10% to +5%. However, the focus of that study was the change in wind shear and the drag coefficient. Herein, the changes in surface turbulent fluxes are examined. For some months and regions, the bias due to ignoring waves can exceed 30Wm-2; however, the biases are usually smaller. Regional and seasonal differences within discussed. Remotely sensed stresses can be used to bypass these issues, and determine more accurate surface turbulent fluxes. Examples will be given for improvements in stress, sensible heat, and latent heat.

Application of Remote Sensing in Decadel Marine Climate Prediction: Challenges and Opportunities in Nigeria

Ediang, A.O[1]; Ediang,A.O (Presenting), [2]
[1]NIGERIAN METEOROLOGICAL AGENCY, NIGERIA; [2]

Despite the importance of the neighbouring oceans to the economies climates and biodiversity of many African countries, decadal marine climate prediction to coastal ocean problems by African scientists is not well developed especially using remote sensing. This limited capacity is associated with relative lack of computational resources and facilities for training in marine and oceanography sciences on the continent, as well as little or no monitoring of coastal waters by local scientists.

The study revealed that presently the marine meteorological stations in Nigeria, by the Nigerian Meteorological Agency, have increased from four to ten stations all situated at the coastline of Nigeria with the observations and forecast issue to potential users.

Some evidences of warming ocean in Nigeria using sea surface temperature(SST) for the period 1989- 2007 which was statistically analysed (Ediang et al 2010), there is some theoretical basis for expecting Changes in their occurrence, associated with changes in background climate state.

The attempt in this study is however to highlight that in Nigeria marine meteorological observations show that the ocean has been changing over the last several decades. Indicating that decadal marine climate prediction is evident in the environment of Nigeria coastal line using remote sensing.

Importance of the deep ocean for estimating decadal changes in Earth's radiation balance

Matthew D. Palmer, Douglas J. McNeall and Nick J. Dunstone*
Met Office Hadley Centre, FitzRoy Road, Exeter, EX1 3PB, United Kingdom
**Corresponding author: matthew.palmer@metoffice.gov.uk*

The lack of global surface temperature rise over the past decade, due largely to a lack of rise in sea surface temperature (SST), has provoked much interest in the scientific community and wider media. Recent research has highlighted an apparent discrepancy between satellite estimates of net top-of-atmosphere radiation balance (TOA) and changes in ocean heat content (OHC). We carry out regression analyses using control run data from three generations of Hadley Centre climate model, to estimate the uncertainty of TOA , given SST or OHC. We show that decadal trends in SST are only weakly indicative of changes in TOA. Trends in OHC, integrated over increasing model levels, provide an increasingly good indication of TOA changes. To achieve a given accuracy in TOA estimated from OHC we find that there is a trade-off between measuring for longer or deeper. Our model results suggest that there is potential for substantial improvement in our ability to monitor Earth's radiation balance by sustained observation of the deep ocean.

Theme 2

Long Term Variability of the Mediterranean Sea Surface Temperature using International Databases including the ICOADS

Iona, S.[1]; Axaopoulos, P.[2]; Sofianos, S.[2]; Zarokanelos, N.[1]; Theodorou, A.[3]
[1]HCMR/HNODC, GREECE; [2]Univ. of Athens, Dept. of Physics, GREECE; [3]Univ. of Thessaly, Lab. of Oceanography, GREECE

The long term variability of the Mediterranean Sea and its sub-basins during the last century is investigated using in situ observations from the ICOADS historical data and aggregated data sets derived from several international databases. These are the MEDAR/MEDATLAS II, data from the Coriolis Operational Data Centre, the World Ocean Database 2005, the ICES Oceanographic Database and national archives from the Hellenic Oceanographic Data Centre. Duplicates have been removed from the merged data sets using spatial and temporal criteria and only data values flagged as "good" retained for further processing.

Analysis of the ICOADS SST time-series revealed a positive trend in both basin and sub-basin scale. During the last century, the highest positive SST trend was found in the Adriatic Sea and the lowest one in the Aegean sea. This difference in the SST evolution of the two sub-basins could have played a role in the shift of the Eastern Mediterranean deep water formation site during the 90s, known as Eastern Mediterranean Transient. Comparison with climatic indexes points out a high correlation of the Western Mediterranean and Adriatic Sea SST with the NAO index, while the Eastern Mediterranean SST variations are highly correlated to the Indian Summer Monsoon Index. Similar patterns are revealed from the analysis of the aggregated datasets from which the bathythermographs are excluded in order to remove the instrumentation errors. Furthermore indices of stratification and thermal/salt content are being calculated in order to identify important processes related to the long term variability of the Mediterranean Sea and its basins.

Creating a Marine Humidity Monitoring Product

Willett, K
UK Met Office, UNITED KINGDOM

Surface humidity is an essential climate variable. Its near real-time monitoring will provide valuable insight into many aspects of the state of our climate, including feedback mechanisms and the radiation budget, the hydrological cycle and the earth energy budget. This requires observations over both the land and oceans that are robust to varying non-climatic influences over time. Recent efforts relating to humidity have mostly been land focused. Reductions in relative humidity since 2000 have been noted over many regions of the global land mass (Simmons et al. 2010). Multi-model comparisons with specific humidity over land have shown the models to do reasonably well over the period 1973-1999 but that there is high model and observation uncertainty in the Southern Hemisphere. This leaves a number of interesting research questions where the complete story can only be obtained by looking at humidity over the oceans.

This poster documents the state of marine humidity to date and plans for a new global near real-time product for monitoring purposes and to further our understanding of the above issues.

Research Vessel Observations: A Modern Data Record for Marine Climatology

Smith, S.[1]; Rolph, J.[2]; Briggs, K.[2]; Bourassa, M.[2]
[1]Florida State University, UNITED STATES; [2]COAPS/FSU, UNITED STATES

The authors will report on ongoing activities within the United States (U. S.) to expand routine acquisition, quality control, and distribution of underway surface marine observations collected by research vessels. The Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative, in partnership with the University-National Oceanographic Laboratory System Rolling Deck to Repository (R2R) project, has recruited 28 research vessels to provide navigational, meteorological, and oceanographic observations on a routine basis to a data assembly center (DAC) at the Florida State University. The authors will highlight efforts to evaluate the quality of the observations, collect essential metadata, provide data quality feedback to vessel operators, and ensure the long term preservation of the data at the U. S. National Oceanographic Data Center. The authors will highlight procedures for submitting these underway observations to the International Comprehensive Ocean Atmosphere Data Set in support of marine climate research.

A SAMOS is typically a computerized data logging system that continuously records navigational (ship position, course, speed, and heading), meteorological (winds, air temperature, pressure, moisture, rainfall, and radiation), and near ocean surface (sea temperature and salinity) parameters while a vessel is underway. Measurements are recorded at high-temporal sampling rates (typically 1 minute or less). A SAMOS comprises scientific instrumentation deployed by the research vessel operator. The instruments are not provided by the SAMOS initiative.

The SAMOS initiative is complementary to the JCOMM[1] Voluntary Observing Ship (VOS) Scheme and some vessels contribute to both programs. Traditional VOS report observations at one to six hour intervals, much less frequently than SAMOS, to meet objectives including the initialization of numerical weather prediction (NWP) models and providing input to marine climate data sets. VOS observations have greater spatial coverage than SAMOS by using a wider range of vessel types–some instrumented with automatic systems and some with basic instrumentation supplemented with visual observations.

Growing interest in climate variability and the need to quantify the role of air-sea fluxes in the coupled ocean-atmosphere system have placed unprecedented observational requirements on marine meteorology. The SAMOS DAC provides high-quality data from ocean regions that are far outside typical VOS shipping routes. These data include extremes in winds, air temperature, humidity, sea temperature, and salinity that are essential for calibrating new satellite sensor and improving retrieval algorithms. The high-temporal frequency of SAMOS data allow accurate collocations of satellite and in situ data that account for random errors imparted by both temporal and spatial separation between observations. SAMOS vessels are also frequently equipped with shortwave, longwave and photosynthetic radiometers, providing unique records over the oceans to validate a wide range of satellite-based products. Additionally, sophisticated air-sea flux instrumentation are available on some vessels, but these sensors are more expensive than conventional automated meteorological sensors, still under development for polar oceans, and currently are deployed only on limited research cruises. SAMOS currently partners with groups deploying these flux systems to provide shipboard comparisons to the instrumentation used to collect SAMOS observations. SAMOS is a pragmatic solution, meeting the requirements for accuracy and temporal and spatial coverage by taking advantage of the existing fleet of suitably equipped RVs.

[1]JCOMM is the Joint World Meteorological Organization (WMO)/Intergovernmental Oceanographic Commission (IOC) Technical Commission for Oceanography and Marine Meteorology.

Advancing the Use of Historical Environmental Data through the Climate Database Modernization Program

Freeman, E[1,4]; Anderson, H[1,4]; Lawrimore, J[1]; Marzin, C[3]; Ross, T[1]; Seiderman, M[1]; Wilkinson, C[5]; Woodruff, S[2]
[1] NOAA National Climatic Data Center, Asheville, NC, USA; [2] NOAA Earth System Research Laboratory, Boulder, Co, USA; [3] NOAA National Marine Sanctuaries, Silver Spring, MD, USA; [4] STG, Inc, Reston, VA, USA; [5]Climatic Research Unit, University of East Anglia, Norwich, UK

NOAA's Climate Database Modernization Program (CDMP) has been rescuing environmental data for more than ten years. During that time, information located on fragile media has been imaged and preserved, and historical data has been digitized to provide access to more than 55 million imaged records previously difficult to obtain or fully unavailable to the public. CDMP rescues many types of data, including ocean, terrestrial, and upper air. By digitizing national and international ship logbooks, global observations over the oceans are being made available to the International Comprehensive Ocean-Atmosphere Dataset (ICOADS) to enhance the spatial and temporal coverage of the most extensive surface marine meteorological archive in the world. Marine rescue efforts are not limited strictly to surface meteorological observations and also include projects related to sub-

surface ocean observations, as well as biological and marine ecosystems information. CDMP coordinates with the RECovery of Logbooks And International Marine data (RECLAIM) project to locate, document and prioritize the rescue of new sources of data and metadata for future projects with the goal of increasing awareness and understanding of historical observing practices as well as augmenting data coverage in sparsely observed areas. Over the past decade, CDMP has also digitized large amounts of terrestrial data from data sparse areas around the globe. These data are essential to the International Surface Temperatures Initiative, a renewed effort at creating a comprehensive international data holding of all land meteorological data to address gaps including inadequate temporal and spatial coverage. By working with private and public sector partners towards a mission to make data available for science, CDMP is advancing understanding of the earth's physical environment and preserving the past for generations to come.

Keying Dutch 19th Century Ships' Logbooks in CDMP

Koek, F.B.
KNMI, NETHERLANDS

The successful project CLIWOC (Climatological database for the World's Oceans: 1750-1850), which ran from 2000-2003, was limited to the years 1750-1850 and - due to lack of time - did not succeed in digitizing all available logbooks. Still a lot of ship logbooks sit in various archives spread around the world and the content is anxiously waiting to be keyed.

After CLIWOC there still remained nearly 200 logbooks in the archives of KNMI that needed to be processed quickly because the state of these logbooks is deteriorating fast. These logbooks contain meteorological data from some 325 ships covering the period 1826-1892, worldwide. In total 17,565 images were made and sent to CDMP (Climate Database Modernization Program) in the USA. The next task will be to digitize all these images and convert them into manageable information in a database.

The first thing to do is getting the images into EDADS (Environmental Document Access and Display System), so they can be accessed on the web. Meanwhile the keying format will be developed. Since the logbooks are generally of the extract-logbook type (registers that were filled in ashore from the original logbooks), the structure of them is very constant. We do not expect major problems with that. However, the language used in these logbooks is Dutch. Keying these data needs close guidance, which we are kindly offering to the CDMP program. Collaboration between KNMI (The Netherlands) and CDMP (USA) will help to build the database quickly. The first keying of these Dutch logbooks is scheduled to commence in June 2011.

Rescue of Historical Data from Land and Sea

Gloeden, Wolfgang; Rosenhagen, Gudrun; Tinz, Birger
Deutscher Wetterdienst, GERMANY

Deutscher Wetterdienst (DWD, German Meteorological Service) in Hamburg has an extensive archive of world-wide original historical weather records from land and sea.

The paper will present the activities of data rescue as an important contribution to world-wide climate monitoring.

The oldest ship logbook is from 1829, but most of the approx. 37.000 meteorological journals of sailing ships and steamers are from 1853 to 1934. These journals are partly scanned and digitized. After the quality check the data are included in ICOADS. A data bank of metadata exists which allows the connection between the data already in the archive and the meteorological journals. With this we are able to identify the type of observation platform and join all journeys ship by ship.

In the colonial period, Deutsche Seewarte also operated a world-wide net of meteorological land stations, many of them situated at the coasts or on islands. The archive consists of data of more than 1500 stations, mostly from the period 1880 to 1918. Some stations even continued into the 1930th. The observation periods range from some months up to 49 years. The historical data are digitized, quality-checked, stored in a data bank and made available to the home countries.

Theme 3

The NOCSv2.0 Surface Flux Dataset

Berry, D. I.; Kent, E. C.
National Oceanography Centre, UNITED KINGDOM

Marine meteorological reports from Voluntary Observing Ships (VOS) such as those in the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) are an important source of information on air-sea heat exchange. ICOADS observations have been used to calculate monthly mean fields of surface heat flux for the period 1973 to 2010 in the NOCSv2.0 surface flux dataset. The flux estimates were made available in mid-2008 via the National Center for Atmospheric Research (NCAR) Computational and Information Systems Laboratory (CISL) Research Data Archive (http://dss.ucar.edu/datasets/ds260.3/) with the support of the NCAR Data Support Section.

NOCS2.0, uses optimal interpolation (OI) to allow estimates of uncertainty to be made. Daily estimates of the basic meteorological variables (wind speed, pressure, air temperature, humidity, sea surface temperature and cloud cover) are made using an optimal interpolation scheme applying bias corrections where possible. These daily fields are then used to calculate daily bulk estimates of sensible, latent, shortwave and longwave heat fluxes. Random measurement uncertainty is accounted for within the OI scheme and the use of daily data enables the sampling uncertainty to be estimated. Bias uncertainty is also estimated.

This presentation will demonstrate some of the strengths and weaknesses of the NOCSv2.0 fluxes as compared to other available flux datasets.

Estimating and Presenting Uncertainties in an Historical Sea-Surface Temperature Analysis

Kennedy, J[1]; Rayner, N[1]; Saunby, M[1]; Smith, R[2]; Parker, D[1]
[1]Met Office Hadley Centre, UNITED KINGDOM; [2]Department of Marine Science, University of Otago, NEW ZEALAND

Historical sea-surface temperature analyses are used in a wide-variety of applications. For many users the ideal SST analysis would have very high temporal and spatial resolution and would look like the best fields that can currently be produced using high-resolution satellite data. Unfortunately, given the sparsity of historical *in situ* observations, this is not possible.

Instead of this, analyses are often presented as a combination of a best-estimate together with an error range. This is a convenient way of expressing the magnitude of the uncertainty in the data, but it does not tell the user how the errors covary. What is their structure? Nor do the fields look like the high resolution fields derived from satellite data.

In developing the HadISST2 data set our aim has been to create an ensemble of equi-probable realisations of the data which are both consistent with the available data, span the range of uncertainty, and which contain 'realistic' temporal and spatial variability at the target resolution.

Improved Estimates of Uncertainty in Gridded Sea-Surface Temperature Data Sets

Kennedy, J[1]; Rayner, N[1]; Smith, R[2]
[1]Met Office Hadley Centre, UNITED KINGDOM; [2]Department of Marine Science, University of Otago, NEW ZEALAND

Measurement errors in *in situ* sea-surface temperature data sets are often partitioned into a random error component, that varies from observation to observation, and a bias term that is assumed to be characteristic of and thus entirely determined by the method by the measurement was taken. For example, it is assumed in current SST data sets that all measurements made using canvas buckets are biased cold in a similar way. The first type of error can be diminished by averaging over many observations, but the second type of error cannot.

We motivate and describe an error model which allows for micro-biases in the data. These are persistent errors that are peculiar to the apparatus and methods applied on a single ship (or buoy). Micro-biases will be constant for a given ship (or buoy), but will vary from one to another. The errors associated with micro-biases are not reduced by averaging many observations from a single ship. They can only be reduced by averaging over observations from a large number of different ships.

When a ship visits different grid boxes, the errors in the average SST measured in the grid boxes that the ship visited will be correlated. These correlated errors increase uncertainties on grid-box, area-average and global-average SSTs particularly at times when observations are few and the global fleet is lacking in diversity.


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